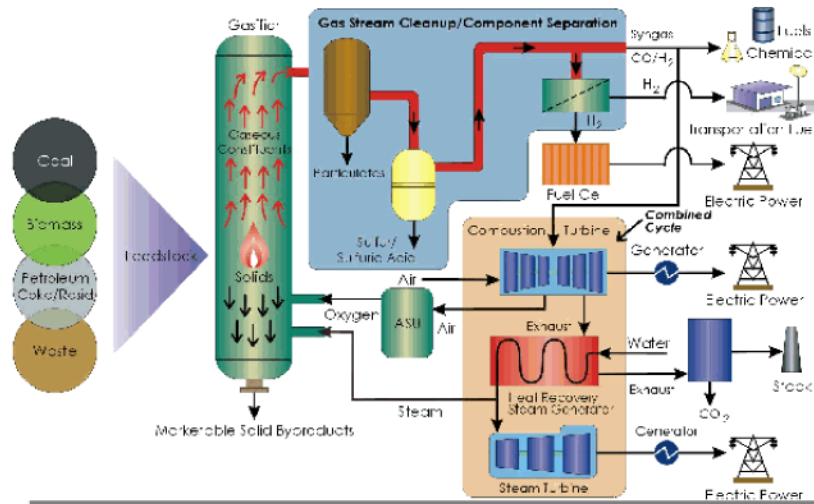


## 2.1.2 HIGH-EFFICIENCY COAL/SOLID FEEDSTOCK

### Technology Description

# Advanced Gasification System



Advanced coal-fired, power-generation technologies can achieve significant reductions in CO<sub>2</sub> emissions while providing a reliable, efficient supply of electricity. Significant improvements in reducing CO<sub>2</sub> have been demonstrated via efficiency improvements and cofiring of coal and biomass. While current power plant efficiencies are about 33%, increasing efficiencies ultimately to 60% or more will reduce CO<sub>2</sub> emissions by more than 50% per unit of electricity. Future development of CO<sub>2</sub> sequestration could reduce carbon emissions to near-zero levels.

### System Concepts

- Gasification technology increases the coal power-generation cycle efficiency by combining two or more energy cycles, a high-temperature gas turbine, and a steam turbine. In a typical configuration, the gasifier converts coal into a low- or medium-BTU gas, which is burned in the combustion section of the gas turbine to produce electric power. The exhaust gases from the gas turbine are cooled in the heat-recovery steam generator. The steam is routed to the steam turbine, producing additional electric power. Depending on the quality of the gas produced, the gas also may be used as the feedstock to coproduce a variety of chemicals and fuels. Steam also may be replaced with a more efficient working fluid (e.g., air or long-term binary mixtures).
- Combustion technology, including chemical looping, may use oxygen separation coupled to a coal-fired power plant featuring oxygen combustion, carbon capture, and ultra-supercritical steam-cycle operation.

### Representative Technologies

- Vision 21 – the ultra-clean energy plant of the future.
- Integrated gasification combined cycle (IGCC).
- Pressurized fluidized bed combustion.
- Oxygen-combustion systems.
- Unconventional combustion (e.g., use of chemical cycling for CO<sub>2</sub> enrichment).

### Technology Status/Applications

- Current IGCC systems based on oxygen-blown, entrained-bed gasifiers are 40%-42% efficient.
- IGCC systems with efficiencies of 40%-45% are scheduled to be available for commercial deployment by 2005.

- Efficiencies of a portfolio of IGCC technologies are expected to average 50% by 2008 and 60% by 2015.
- The cost of electricity for these technologies is expected to be 3¢–4¢/kWh (in 1997\$) by 2015.
- Gasifier capital costs are expected to decrease to 90% of current costs as these technologies mature around 2010.
- Supercritical coal-fired technologies without carbon sequestration are available now with efficiencies of 42%.
- Ultra-critical steam cycles using coal-fired technologies with efficiencies in the 45% range are expected by 2010.
- Coal-fired technologies with significant potential for carbon capture are expected by 2015.
- Oxygen-fed, coal-fired power plants with near-zero CO<sub>2</sub> emissions are expected by 2020.

### **Current Research, Development, and Demonstration**

#### **R&D Goals**

- Current DOE RD&D program efficiency goals range from 48%-52% in 2008 to more than 60% in 2015 at an electricity cost that is 75%-90% of current pulverized-coal-based generation.
- Emissions of criteria pollutants are targeted to be much less than one-tenth of current new source performance standards.

#### **RD&D Challenges**

- Long-term systems need to maintain relatively high temperatures between the combustion/gasification stage and the turbine stage to achieve efficiency goals.
- High-temperature materials that are stable and resistant to corrosion, erosion, and decrepitation are a primary technology development need.
- Long-term materials are needed for heat exchangers, turbine components, particulate filters, and SO<sub>2</sub> removal. Other challenges include the use of alternate working fluids and heat-exchange cycles, CO<sub>2</sub> capture methods, cycle optimization, environmental control technologies with low energy penalties, and solids handling.

#### **RD&D Activities**

- The portfolio of high-efficiency coal power systems under development through DOE is comprised of IGCC, pressurized fluidized bed combustion, and Vision 21 plants.
- DOE activities are supplemented by up to 50% cost share from the private sector.
- Current development encompasses a broad range of activities including major efforts by UNDERC, Southern Company Services, and others to develop a new class of gasifiers.
- Four IGCC clean coal demonstration projects are in various stages of completion.

### **Recent Progress**

- In 1996, the IGCC Wabash River project received *Power Magazine's* Power Plant of the Year Award, "a technology to bridge the millennium...to minimize environmental impact and maximize efficiency." As one of 40 projects in the Clean Coal Technology Program, the 260-MW Wabash River repowering project increased the efficiency of an older pulverized coal unit by one-third, to 39% efficiency. Since starting in 1995, Wabash has operated more than 15,000 hours, consuming more than 1.5 Mt of coal to produce more than 4 GWh of electricity.
- In July 1996, the Polk Power Station of Tampa Electric Company began operating their gasifier. Since then, the gasifier has operated more than 25,700 hours to produce more than 7.4 GWh of electricity. During 2000, the Polk Power Stations' gasifier reached its project goal of 80% online availability. The project was presented the 1997 Power Plant Award by *Power Magazine*. Sulfur capture for the project is greater than 98%, while NO<sub>x</sub> emissions are 75% less than a conventional pulverized coal-fired power plant.

### **Commercialization and Deployment Activities**

- The gasification technology is under development with several recent proof-of-concept greenfield and repowering installations. Existing plants may be repowered with higher-efficiency coal technologies at or below the price of the natural gas combined-cycle plants. Where natural gas is not available (a considerable portion of the United States and a major portion of the international market) or if gas costs stay above \$4/mmbtu, high-efficiency coal plants will be the lowest-cost choice.
- Internationally, where natural gas is not available, the market share for coal is expected to be much higher.

#### **Market Context**

- The market for new or repowered capacity from now until 2020 is estimated to be as much as 400 GW in the United States and more than that internationally. Domestically, the primary competition for this technology profile is expected to be natural gas combined cycle.